

## WEST Search History

[Hide Items](#)[Restore](#)[Clear](#)[Cancel](#)

DATE: Wednesday, December 07, 2005

<b>Hide?</b>	<b><u>Set Name</u></b>	<b><u>Query</u></b>	<b><u>Hit Count</u></b>
		<i>DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI; THES=ASSIGNEE; PLUR=YES; OP=ADJ</i>	
<input type="checkbox"/>	L3	L2 and heat exchanger\$1	11
<input type="checkbox"/>	L2	L1 and (synthesis gas or syngas or hydrogen near1 carbon monoxide)	12
<input type="checkbox"/>	L1	microreactor same microchannel\$1 and fischer tropsch	21

END OF SEARCH HISTORY

Connecting via Winsock to STN

Welcome to STN International! Enter x:x

LOGINID:ssspta1202jxp

PASSWORD:

TERMINAL (ENTER 1, 2, 3, OR ?):2

\* \* \* \* \* Welcome to STN International \* \* \* \* \*

NEWS 1 Web Page URLs for STN Seminar Schedule - N. America  
NEWS 2 "Ask CAS" for self-help around the clock  
NEWS 3 SEP 09 ACD predicted properties enhanced in REGISTRY/ZREGISTRY  
NEWS 4 OCT 03 MATHDI removed from STN  
NEWS 5 OCT 04 CA/Caplus-Canadian Intellectual Property Office (CIPO) added  
to core patent offices  
NEWS 6 OCT 13 New CAS Information Use Policies Effective October 17, 2005  
NEWS 7 OCT 17 STN(R) AnaVist(TM), Version 1.01, allows the export/download  
of Caplus documents for use in third-party analysis and  
visualization tools  
NEWS 8 OCT 27 Free KWIC format extended in full-text databases  
NEWS 9 OCT 27 DIOGENES content streamlined  
NEWS 10 OCT 27 EPFULL enhanced with additional content  
NEWS 11 NOV 14 CA/Caplus - Expanded coverage of German academic research  
NEWS 12 NOV 30 REGISTRY/ZREGISTRY on STN(R) enhanced with experimental  
spectral property data  
NEWS 13 DEC 05 CASREACT(R) - Over 10 million reactions available  
  
NEWS EXPRESS DECEMBER 02 CURRENT VERSION FOR WINDOWS IS V8.01,  
CURRENT MACINTOSH VERSION IS V6.0c(ENG) AND V6.0Jc(JP),  
AND CURRENT DISCOVER FILE IS DATED 02 DECEMBER 2005.  
V8.0 USERS CAN OBTAIN THE UPGRADE TO V8.01 AT  
<http://download.cas.org/express/v8.0-Discover/>  
  
NEWS HOURS STN Operating Hours Plus Help Desk Availability  
NEWS INTER General Internet Information  
NEWS LOGIN Welcome Banner and News Items  
NEWS PHONE Direct Dial and Telecommunication Network Access to STN  
NEWS WWW CAS World Wide Web Site (general information)

Enter NEWS followed by the item number or name to see news on that  
specific topic.

All use of STN is subject to the provisions of the STN Customer  
agreement. Please note that this agreement limits use to scientific  
research. Use for software development or design or implementation  
of commercial gateways or other similar uses is prohibited and may  
result in loss of user privileges and other penalties.

\* \* \* \* \* STN Columbus \* \* \* \* \*

FILE 'HOME' ENTERED AT 17:26:23 ON 07 DEC 2005

=> FIL STNGUIDE

COST IN U.S. DOLLARS

FULL ESTIMATED COST

SINCE FILE	TOTAL
ENTRY	SESSION
0.21	0.21

FILE 'STNGUIDE' ENTERED AT 17:26:31 ON 07 DEC 2005  
USE IS SUBJECT TO THE TERMS OF YOUR CUSTOMER AGREEMENT  
COPYRIGHT (C) 2005 AMERICAN CHEMICAL SOCIETY, JAPAN SCIENCE  
AND TECHNOLOGY CORPORATION, AND FACHINFORMATIONSZENTRUM KARLSRUHE

FILE CONTAINS CURRENT INFORMATION.  
LAST RELOADED: Dec 2, 2005 (20051202/UP).

=> FIL HOME

COST IN U.S. DOLLARS	SINCE FILE ENTRY	TOTAL SESSION
FULL ESTIMATED COST	0.06	0.27

FILE 'HOME' ENTERED AT 17:26:39 ON 07 DEC 2005

=> file caplus

COST IN U.S. DOLLARS	SINCE FILE ENTRY	TOTAL SESSION
FULL ESTIMATED COST	0.21	0.48

FILE 'CAPLUS' ENTERED AT 17:26:49 ON 07 DEC 2005  
USE IS SUBJECT TO THE TERMS OF YOUR STN CUSTOMER AGREEMENT.  
PLEASE SEE "HELP USAGETERMS" FOR DETAILS.  
COPYRIGHT (C) 2005 AMERICAN CHEMICAL SOCIETY (ACS)

Copyright of the articles to which records in this database refer is held by the publishers listed in the PUBLISHER (PB) field (available for records published or updated in Chemical Abstracts after December 26, 1996), unless otherwise indicated in the original publications. The CA Lexicon is the copyrighted intellectual property of the American Chemical Society and is provided to assist you in searching databases on STN. Any dissemination, distribution, copying, or storing of this information, without the prior written consent of CAS, is strictly prohibited.

FILE COVERS 1907 - 7 Dec 2005 VOL 143 ISS 24  
FILE LAST UPDATED: 6 Dec 2005 (20051206/ED)

Effective October 17, 2005, revised CAS Information Use Policies apply. They are available for your review at:

<http://www.cas.org/infopolicy.html>

=> s microreactor and microchannel

- 3337 MICROREACTOR
- 1803 MICROREACTORS
- 4080 MICROREACTOR
- (MICROREACTOR OR MICROREACTORS)
- 4753 MICROCHANNEL
- 2264 MICROCHANNELS
- 5866 MICROCHANNEL
- (MICROCHANNEL OR MICROCHANNELS)

L1 284 MICROREACTOR AND MICROCHANNEL

=> s l1 and fischer tropisch

- 23202 FISCHER
- 15 FISCHERS
- 23214 FISCHER
- (FISCHER OR FISCHERS)
- 7791 TROPSCH
- 7690 FISCHER TROPSCH
- (FISCHER(W)TROPSCH)

L2 9 L1 AND FISCHER TROPSCH

=> d 12 ibib ab 1-9

L2 ANSWER 1 OF 9 CAPLUS COPYRIGHT 2005 ACS on STN  
ACCESSION NUMBER: 2005:735342 CAPLUS  
DOCUMENT NUMBER: 143:195591  
TITLE: Process for conducting an equilibrium limited chemical  
reaction using microchannel technology  
INVENTOR(S): Tonkovich, Anna Lee; Paul, Jarosch Kai Tod; Mazanec,  
Terry; Daly, Francis P.; Taha, Rachid; De Alba,  
Enrique Aceves  
PATENT ASSIGNEE(S): USA  
SOURCE: U.S. Pat. Appl. Publ., 33 pp.  
CODEN: USXXCO  
DOCUMENT TYPE: Patent  
LANGUAGE: English  
FAMILY ACC. NUM. COUNT: 1  
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
US 2005176832	A1	20050811	US 2004-777033	20040211
WO 2005082519	A1	20050909	WO 2005-US623	20050107
W:	AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW			
RW:	BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR, BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG			

PRIORITY APPLN. INFO.: US 2004-777033 A 20040211  
AB The invention relates to a process for conducting an equilibrium limited chemical reaction in a microchannel reactor. The process involves the use of active heat exchange and is suitable for conducting exothermic and endothermic reactions. The process comprises: (A) determining the equilibrium conversion value for the primary reactant in the reactant composition at the first reaction temperature and at another reaction temperature; (B) passing the reaction composition through a first reaction zone in the reactor at the first reaction temperature in contact with a first catalyst to form an intermediate product composition so that the approach to conversion of the primary reactant is  $\geq 5\%$ ; and (C) passing the intermediate product composition into another reaction zone in contact with another catalyst to form the desired product so that the approach to conversion conversion of the primary reactant is  $\geq 5\%$ . The process is particularly suitable for synthesizing methanol and di-Me ether.

L2 ANSWER 2 OF 9 CAPLUS COPYRIGHT 2005 ACS on STN  
ACCESSION NUMBER: 2005:538848 CAPLUS  
DOCUMENT NUMBER: 143:45768  
TITLE: Microreactors for Syngas Conversion to Higher Alkanes: Characterization of Sol-Gel-Encapsulated Nanoscale Fe-Co Catalysts in the Microchannels  
AUTHOR(S): Nagineni, Venkata S.; Zhao, Shihuai; Potluri, Avinash; Liang, Yu; Siriwardane, Upali; Seetala, Naidu V.; Fang, Ji; Palmer, James; Kuila, Debasish  
CORPORATE SOURCE: Institute for Micromanufacturing (IfM), Louisiana Tech University, Ruston, LA, 71272, USA  
SOURCE: Industrial & Engineering Chemistry Research (2005),

44(15), 5602-5607  
CODEN: IECRED; ISSN: 0888-5885  
PUBLISHER: American Chemical Society

DOCUMENT TYPE: Journal  
LANGUAGE: English

AB Silicon microreactors were coated with mixed-metal Fe-Co Fischer-Tropsch catalysts in alumina sol-gel for conversion of syngas (CO + H<sub>2</sub>) to higher alkanes. Characterization of the nanocatalysts using SEM, energy-dispersive x-ray, atomic force microscopy, and Brunauer-Emmett-Teller surface area measurements, packaging, and the reaction results from a mass spectrometer at controlled temps. (200-260°) and pressure (1 atm) with varying H<sub>2</sub>:CO ratios from 1:1 to 10:1 are described. The catalyst does not adequately infiltrate the 5-μm channels; it coats nicely the 25-μm channels. The initial results are consistent with a lower conversion of CO (.apprx.32%) in a 5-μm-channel reactor and a higher conversion (.apprx.52%) in a 25-μm-channel reactor. The selectivity to propane (.apprx.80%) is not affected by the width of the microchannels. The activity of the sol-gel-encapsulated catalyst before and after the reactions is estimated from its magnetic properties using a vibrating sample magnetometer.

REFERENCE COUNT: 40 THERE ARE 40 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L2 ANSWER 3 OF 9 CAPLUS COPYRIGHT 2005 ACS on STN

ACCESSION NUMBER: 2005:213556 CAPLUS

DOCUMENT NUMBER: 143:268670

TITLE: Microprocess technology for Fischer-Tropsch gas-to-liquids

AUTHOR(S): Wang, Yong; Hu, J.; Cao, C.; Mazanec, T. J.

CORPORATE SOURCE: Pacific Northwest National Laboratory, Richland, WA, 99352, USA

SOURCE: Preprints - American Chemical Society, Division of Petroleum Chemistry (2005), 50(1), 69-70

CODEN: ACPCAT; ISSN: 0569-3799

PUBLISHER: American Chemical Society, Division of Petroleum Chemistry

DOCUMENT TYPE: Journal

LANGUAGE: English

AB Structured Co based-engineered catalysts exhibited high activity in Fischer-Tropsch synthesis, especially when integrated with a microchannel reactor, due to improved heat and mass transfer. Higher CO conversion with lower methane selectivity was achieved even under unfavorable reaction conditions in conventional Fischer-Tropsch synthesis. With the use of the engineered catalyst in the microchannel reactor, it was possible to operate Fischer-Tropsch synthesis at temps. much higher than those at which conventional packed bed or slurry reactors are operated while the reaction is still controlled in the nearly isothermal regime. Therefore, the productivity can be enhanced by a factor of three to twelve in comparison with conventional Fischer-Tropsch reactors. The unique microchannel reactor design and its integration with engineered catalyst allow operation of the Fischer-Tropsch reaction under a wide temperature range and flexibility to obtain different products.

REFERENCE COUNT: 1 THERE ARE 1 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L2 ANSWER 4 OF 9 CAPLUS COPYRIGHT 2005 ACS on STN

ACCESSION NUMBER: 2004:331557 CAPLUS

DOCUMENT NUMBER: 140:341237

TITLE: Catalysts, in microchannel apparatus, concentration gradients, and reactions using same

INVENTOR(S): Manzanec, Terry J.; Wang, Yong; Silva, Laura J.; Vander Wiel, David P.

PATENT ASSIGNEE(S): USA  
 SOURCE: U.S. Pat. Appl. Publ., 22 pp.  
 CODEN: USXXCO  
 DOCUMENT TYPE: Patent  
 LANGUAGE: English  
 FAMILY ACC. NUM. COUNT: 1  
 PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
US 2004076562	A1	20040422	US 2002-279089	20021022
CA 2503194	AA	20040506	CA 2003-2503194	20031017
WO 2004037418	A2	20040506	WO 2003-US33104	20031017
WO 2004037418	A3	20040916		

W: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW

RW: GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR, BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG

EP 1556165	A2	20050727	EP 2003-809579	20031017
------------	----	----------	----------------	----------

R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, SI, LT, LV, FI, RO, MK, CY, AL, TR, BG, CZ, EE, HU, SK

PRIORITY APPLN. INFO.: US 2002-279089 A 20021022  
 WO 2003-US33104 W 20031017

AB The present invention provides new **microreactor** systems, catalysts, and chemical processes. Methods of making novel catalysts and reaction apparatus are also described.

L2 ANSWER 5 OF 9 CAPLUS COPYRIGHT 2005 ACS on STM

ACCESSION NUMBER: 2004:224074 CAPLUS

TITLE: **Microreactors** for catalysis using nano-catalysts

AUTHOR(S): Kuila, Debasish; Zhao, Shihuai; Nagineni, Venkata S.; Potluri, Avinash; Indukuri, H.; Liang, Yu; Cao, W.; Hu, J.; Fang, Ji; Varahramyan, K.; Nassar, Raja; Palmer, James; Siriwardane, Upali; Naidu, Seetala V.

CORPORATE SOURCE: Institute for Micromanufacturing/Chemistry, Louisiana Tech University, Ruston, LA, 71272, USA

SOURCE: Abstracts of Papers, 227th ACS National Meeting, Anaheim, CA, United States, March 28-April 1, 2004 (2004), COLL-473. American Chemical Society: Washington, D. C.

CODEN: 69FGKM

DOCUMENT TYPE: Conference; Meeting Abstract

LANGUAGE: English

AB **Microchannel microreactors** based on Si (5-100  $\mu$ ) have been used to study heterogeneous catalysis of three significant reactions: hydrogenation and dehydrogenation of cyclohexene, preferential oxidation for CO amelioration in feed for Proton Exchange Membrane (PEM) based fuel cells and **Fischer-Tropsch** synthesis to higher alkane fuels. For the prototype reaction, a 95 % conversion of cyclohexene has been achieved with sputtered and sol-gel coated platinum catalyst. Conversion of synthesis gas (CO:H<sub>2</sub>) to higher alkanes (.apprx. 75% with a selectivity to propane of 80%) and carbon monoxide to carbon dioxide (.apprx. 90% conversion with a selectivity of 90% to CO<sub>2</sub>) to process the feed gas have also been quite successful. The nano-catalysts for these processes have been characterized using SEM, EDX, AFM, VSM and BET surface area measurements. A parallel-array of reactors has been developed for multiple reaction studies and catalyst screening. Design of

expts. for these reactions will be presented.

L2 ANSWER 6 OF 9 CAPLUS COPYRIGHT 2005 ACS on STN

ACCESSION NUMBER: 2004:89738 CAPLUS  
DOCUMENT NUMBER: 141:108227  
TITLE: Nanoscale platinum and iron-cobalt catalysts deposited  
in microchannel microreactors for  
use in hydrogenation and dehydrogenation of  
cyclohexene, selective oxidation of carbon monoxide  
and fischer-tropsch process to  
higher alkanes  
AUTHOR(S): Zhao, Shihuai  
CORPORATE SOURCE: Louisiana Tech. Univ., Ruston, LA, USA  
SOURCE: (2003) 142 pp. Avail.: UMI, Order No. DA3084550  
From: Diss. Abstr. Int., B 2003, 64(3), 1376  
DOCUMENT TYPE: Dissertation  
LANGUAGE: English  
AB Unavailable

L2 ANSWER 7 OF 9 CAPLUS COPYRIGHT 2005 ACS on STN

ACCESSION NUMBER: 2003:930877 CAPLUS  
DOCUMENT NUMBER: 139:397276  
TITLE: Reactors with varying cross-section and their  
manufacture for reactions conducted under varying  
local contact time  
INVENTOR(S): Wang, Yong; Cao, Chunshe; Kimble, James B.; Silva,  
Laura J.  
PATENT ASSIGNEE(S): USA  
SOURCE: U.S. Pat. Appl. Publ., 13 pp.  
CODEN: USXXCO  
DOCUMENT TYPE: Patent  
LANGUAGE: English  
FAMILY ACC. NUM. COUNT: 1  
PATENT INFORMATION:

PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
US 2003219903	A1	20031127	US 2002-153577	20020521
CA 2486379	AA	20031204	CA 2003-2486379	20030521
WO 2003099429	A1	20031204	WO 2003-US16189	20030521
W:	AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW			
RW:	GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR, BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG			
EP 1511561	A1	20050309	EP 2003-755442	20030521
R:	AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, SI, LT, LV, FI, RO, MK, CY, AL, TR, BG, CZ, EE, HU, SK			
PRIORITY APPLN. INFO.:			US 2002-153577	A 20020521
			WO 2003-US16189	W 20030521

AB Chemical reactions are conducted in a reaction microchannel that has a varying cross-sectional area such that a chemical reactant or reactants experience varying local contact time as the reactant(s) flow through the channel. The reactors have multiple reaction microchannels with varying cross-sectional areas. The reaction channel section has a trapezoidal shape that becomes broader from the inlet toward the outlet.

L2 ANSWER 8 OF 9 CAPLUS COPYRIGHT 2005 ACS on STN

ACCESSION NUMBER: 2003:632804 CAPLUS

TITLE: Microreactors for catalysis  
AUTHOR(S): Kuila, D.; Nagineni, Venkata S.; Potluri, Avinash;  
Zhao, Shihuai; Aithal, Rajendra K.; Liang, Yu; Fang,  
Ji; Nassar, Raja; Siriwardane, Upali; Naidu, Seetala  
V.; Palmer, James  
CORPORATE SOURCE: Institute for Micromanufacturing/Chemistry, Louisiana  
Tech University, Ruston, LA, 71272, USA  
SOURCE: Abstracts of Papers, 226th ACS National Meeting, New  
York, NY, United States, September 7-11, 2003 (2003),  
INOR-022. American Chemical Society: Washington, D.  
C.  
CODEN: 69EKY9  
DOCUMENT TYPE: Conference; Meeting Abstract  
LANGUAGE: English

AB Microreactors provide distinct advantages to energy related projects on fuel cells and, in general, on production and processing of fuels. The first advantage of microreactors is the small phys. size of the overall device that allows rapid heat and mass transfer in contrast to conventional reactors. The second advantage is indeed one of the major thrusts of our research: the creation of parallel-array based reactors for rapid catalyst screening. The small catalyst and reactant requirements and fast thermal cycling yield an ideal environment for process development as evidenced by UOP joining the growing number of major companies conducting microreactor research. Microreactors provide the necessary link between the highly combinatorial titer plate approaches that provide no kinetic information and the detailed but time consuming industrial pilot scale packed bed reactors. Our current projects, supported by NSF-EPSCoR and DOE, are addressing the development and characterization of nano-scale metal catalysts using various technologies for conversion of synthesis gas to higher alkane fuels (Fischer-Tropsch process) that is not achievable using conventional fixed bed reactors due to the reaction's high exothermicity. The synthesis of higher alkanes using nano-catalysts of Fe/Co and their fabrication in the microchannels using sol-gel support and their characterization by techniques such as XPS, SEM, EDX, AFM, vibrating sample magnetometer (VSM) and surface area measurement (BET method) will be described. Our progress on modeling of this reaction to optimize the yield and selectivity will also be presented.

L2 ANSWER 9 OF 9 CAPLUS COPYRIGHT 2005 ACS on STN  
ACCESSION NUMBER: 2003:630222 CAPLUS  
TITLE: Microchannel catalytic process for  
converting biomass derived syngas to transportation  
fuels  
AUTHOR(S): Cao, Chunshe; Wang, Yong; Elliott, Douglas C.; Hu,  
John; Stevens, Don  
CORPORATE SOURCE: Pacific Northwest National Laboratory, Richland, WA,  
99352, USA  
SOURCE: Abstracts of Papers, 226th ACS National Meeting, New  
York, NY, United States, September 7-11, 2003 (2003),  
CATL-013. American Chemical Society: Washington, D.  
C.  
CODEN: 69EKY9  
DOCUMENT TYPE: Conference; Meeting Abstract  
LANGUAGE: English

AB Biomass gasification process provides feedstock for Fischer-Tropsch synthesis to produce liquid transportation fuels and chems. Compared to the conventional petroleum/natural gas based GTL technol., biomass-derived feedstock has the nature of small scale, and the use of microchannel reactor technol. is potentially cost-competitive. Battelle/PNNL has developed a catalytic microchannel reactor integrated with highly efficient heat exchanger to provide isothermal environment for the strongly exothermic FT synthesis reactions. It allows the process be operated close to the kinetically controlled regime so that



the heat and mass transfer limitation be minimized in this three phase reaction system. In order to achieve high yield of naphtha and diesel range of hydrocarbons (C5-C19), we have developed a unique structured catalyst system suitable for the deployment in **microchannel** reactor applications. This engineered catalyst structures are based on metallic monolith supports and uniformly coated with improved catalyst formulation. The objective was to take advantage of the high thermal conductivity and reduced mass transfer resistance in an ordered structure. It has been demonstrated that this engineered catalyst produces much narrower carbon distributions (mainly less than C25) than a conventional powder catalyst with the similar productivity and methane selectivity. In particular, majority of the synthesis products fall in to the slates of gasoline and diesel range. This unique product distribution, in turn, has a pos. impact on process economics since there is a strong possibility to eliminate a hydrocracker in downstream processing. In addnl. to the exptl. work, the finite element method (FEM) modeling that efficiently solves the reacting transport problems in complex geometries has been used to optimize the reactor and catalyst design. Numerical simulation in predicting the temperature and conversion profiles in the **microreactor** helps to design the reactor channel geometries. And the simulation of component concentration profile assists to tailor the coating thickness of structured catalyst in order to evaluate the diffusion effects on product selectivity. This optimization improves the performance of monolithic catalysts integrated with **microchannel** reactors for biomass-derived syngas conversion to fuels.

## Hit List

[First Hit](#)[Clear](#)[Generate Collection](#)[Print](#)[Fwd Refs](#)[Bkwd Refs](#)[Generate OACS](#)

Search Results - Record(s) 1 through 11 of 11 returned.

☐ 1. Document ID: US 20050239910 A1

Using default format because multiple data bases are involved.

L3: Entry 1 of 11

File: PGPB

Oct 27, 2005

PGPUB-DOCUMENT-NUMBER: 20050239910

PGPUB-FILING-TYPE: new

DOCUMENT-IDENTIFIER: US 20050239910 A1

TITLE: Fluidization and solids processing in microchannel devices

PUBLICATION-DATE: October 27, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Jarosch, Kai	Bexley	OH	US
Tonkovich, Anna Lee	Marysville	OH	US
Hesse, David J.	Columbus	OH	US
Daymo, Eric	Marysville	OH	US
Perry, Steven T.	Galloway	OH	US
Silva, Laura J.	Dublin	OH	US

US-CL-CURRENT: 518/726

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	Drawings	Drawings
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	----------	----------

☐ 2. Document ID: US 20050009175 A1

L3: Entry 2 of 11

File: PGPB

Jan 13, 2005

PGPUB-DOCUMENT-NUMBER: 20050009175

PGPUB-FILING-TYPE: new

DOCUMENT-IDENTIFIER: US 20050009175 A1

TITLE: Chemical processing microsystems comprising high-temperature parallel flow microreactors

PUBLICATION-DATE: January 13, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Bergh, H. Sam	Santa Clara	CA	US

Guan, Shenheng

Santa Clara

CA

US

## ASSIGNEE-INFORMATION:

NAME	CITY	STATE	COUNTRY	TYPE CODE
Symyx Technologies, Inc.				02

APPL-NO: 10/913049 [PALM]

DATE FILED: August 5, 2004

## RELATED-US-APPL-DATA:

child 10913049 A1 20040805

parent continuation-of 09728732 20001128 US PENDING

child 09728732 20001128 US

parent division-of 09518794 20000303 US GRANTED

parent-patent 6749814 US

non-provisional-of-provisional 60122704 19990303 US

INT-CL: [07] C12 M 1/34

US-CL-PUBLISHED: 435/287.2

US-CL-CURRENT: 435/287.2

REPRESENTATIVE-FIGURES: NONE

## ABSTRACT:

A chemical processing microsystem useful for identifying and optimizing materials (e.g., catalysts) that enhance chemical processes or for characterizing and/or optimizing chemical processes is disclosed. The chemical processing microsystem comprises a plurality of microreactors 600 and, in a preferred embodiment, a plurality of microseparators 900 integral with the chemical processing microsystem 10. The microreactors 600 are preferably diffusion-mixed microreactors formed in a plurality of laminae that include a modular, interchangeable candidate-material array 100. The material array 100 comprises a plurality of different candidate materials (e.g., catalysts), preferably arranged at separate, individually addressable portions of a substrate (e.g., wafer). The microseparators 900 are similarly formed in a plurality of laminae that include a modular, interchangeable adsorbent array 700. The adsorbent array 700 comprises one or more adsorbents, preferably arranged at separate, individually addressable portions of a substrate to spatially correspond to the plurality of different candidate materials. Modular microfluidic distribution systems are also disclosed. The chemical processing microsystem can be integrated into a material evaluation system that enables a comprehensive combinatorial material science research program.

[0001] This application claims priority to commonly owned, co-pending U.S. patent application Ser. No. 60/122,704 filed Mar. 3, 1999, entitled "Chemical Processing Microsystems, Diffusion-Mixed Microreactors and Methods for Preparing and Using Same", which is hereby incorporated by reference for all purposes.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	RMIC	Drawings
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	------	----------

☐ 3. Document ID: US 20040033455 A1

L3: Entry 3 of 11

File: PGPB

Feb 19, 2004

PGPUB-DOCUMENT-NUMBER: 20040033455  
PGPUB-FILING-TYPE: new  
DOCUMENT-IDENTIFIER: US 20040033455 A1

TITLE: Integrated combustion reactors and methods of conducting simultaneous endothermic and exothermic reactions

PUBLICATION-DATE: February 19, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Tonkovich, Anna Lee	Marysville	OH	US
Roberts, Gary	West Richland	WA	US
Fitzgerald, Sean P.	Columbus	OH	US
Neagle, Paul W.	Westerville	OH	US
Qiu, Dongming	Dublin	OH	US
Schmidt, Matthew B.	Columbus	OH	US
Perry, Steven T.	Galloway	OH	US
Hesse, David J.	Columbus	OH	US
Luzenski, Robert J.	Marysville	OH	US
Chadwell, G. Bradley	Reynoldsburg	OH	US
Peng, Ying	Columbus	OH	US
Mathias, James A.	Columbus	OH	US
Gano, Nathan P.	Dublin	OH	US
Long, Richard Q.	Columbus	OH	US
Roger, Wm. Allen	Marysville	OH	US
Arora, Ravi	Dublin	OH	US
Simmons, Wayne W.	Dublin	OH	US
Yang, Barry L.	Dublin	OH	US
Kuhlmann, David J.	Powell	OH	US
Wang, Yong	Richland	WA	US
Yuschak, Thomas D.	Dublin	OH	US
Forte, Thomas	Columbus	OH	US
Monahan, John Arthur	Westerville	OH	US
Jetter, Robert	Pebble Beach	CA	US

APPL-NO: 10/222196 [PALM]  
DATE FILED: August 15, 2002

INT-CL: [07] F23 D 3/40

US-CL-PUBLISHED: 431/7; 431/10, 431/326, 431/170  
US-CL-CURRENT: 431/7; 431/10, 431/170, 431/326

REPRESENTATIVE-FIGURES: 1

ABSTRACT:

Integrated Combustion Reactors (ICRS) and methods of making ICRs are described in

which combustion chambers (or channels) are in direct thermal contact to reaction chambers for an endothermic reaction. Particular reactor designs are also described. Processes of conducting reactions in integrated combustion reactors are described and results presented. Some of these processes are characterized by unexpected and superior results, and/or results that can not be achieved with any prior art devices.

## OTHER APPLICATIONS

[0001] The invention may be further understood by reference to U.S. patent applications Ser. Nos. \_\_\_\_\_ (Title: Multistream Microchannel Device; Attorney Docket No. 02-001), \_\_\_\_\_ (Title: Process for Cooling a Product in a Heat Exchanger Employing Microchannels for the Flow of Refrigerant and Product, Attorney Docket No. 01-002), and \_\_\_\_\_ (Title: Process for Conducting an Equilibrium Limited Chemical Reaction in a Single Stage Process Channel; Attorney Docket No. 02-051), all of which were filed on Aug. 15, 2002, all of which are incorporated herein by reference.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	EMC	Grand
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----	-------

☒ 4. Document ID: US 20040031592 A1

L3: Entry 4 of 11

File: PGPB

Feb 19, 2004

PGPUB-DOCUMENT-NUMBER: 20040031592

PGPUB-FILING-TYPE: new

DOCUMENT-IDENTIFIER: US 20040031592 A1

TITLE: Multi-stream microchannel device

PUBLICATION-DATE: February 19, 2004

## INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Mathias, James Allen	Columbus	OH	US
Chadwell, G. Bradley	Reynoldsburg	OH	US
Qiu, Dongming	Dublin	OH	US
Tonkovich, Anna Lee Y.	Marysville	OH	US
Perry, Steven T.	Galloway	OH	US
Schmidt, Matthew B.	Columbus	OH	US

APPL-NO: 10/222604 [PALM]

DATE FILED: August 15, 2002

INT-CL: [07] F28 D 15/00

US-CL-PUBLISHED: 165/104.19

US-CL-CURRENT: 165/104.19

REPRESENTATIVE-FIGURES: 1A

## ABSTRACT:

The invention is a process and device for exchanging heat energy between three or more streams in a microchannel heat exchanger which can be integrated with a microchannel reactor to form an integrated microchannel processing unit. The invention enables the combining of a plurality of integrated microchannel devices to provide the benefits of large-scale operation. In particular, the microchannel heat exchanger of the present invention enables flexible heat transfer between multiple streams and total heat transfer rates of about 1 Watt or more per core unit volume expressed as W/cc.

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to the following commonly-assigned applications filed concurrently herewith on Aug. 15, 2002: "Integrated Combustion Reactors and Methods of Conducting Simultaneous Endothermic and Exothermic Reactions", Attorney Docket No. 02-052 and "Process for Cooling a Product in a Heat Exchanger Employing Microchannels for the Flow of Refrigerant and Product", Attorney Docket No. 01-002 which applications are incorporated herein by reference.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	Prior Art	Grand
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----------	-------

☐ 5. Document ID: US 20030072699 A1

L3: Entry 5 of 11

File: PGPB

Apr 17, 2003

PGPUB-DOCUMENT-NUMBER: 20030072699

PGPUB-FILING-TYPE: new

DOCUMENT-IDENTIFIER: US 20030072699 A1

TITLE: Integrated reactors, methods of making same, and methods of conducting simultaneous exothermic and endothermic reactions

PUBLICATION-DATE: April 17, 2003

## INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Tonkovich, Anna Lee	Marysville	OH	US
Roberts, Gary	West Richland	WA	US
Perry, Steven T.	Galloway	OH	US
Fitzgerald, Sean P.	Columbus	OH	US

APPL-NO: 10/076875 [PALM]

DATE FILED: February 14, 2002

## RELATED-US-APPL-DATA:

child 10076875 A1 20020214

parent continuation-in-part-of 09375614 19990817 US PENDING

child 10076875 A1 20020214

parent continuation-in-part-of 09640930 20000817 US GRANTED

parent-patent 6378278 US

non-provisional-of-provisional 60269628 20010216 US

INT-CL: [07] B01 J 8/02, B01 J 8/04

US-CL-PUBLISHED: 422/190; 422/188, 422/211, 422/240

US-CL-CURRENT: 422/190; 422/188, 422/211, 422/240

REPRESENTATIVE-FIGURES: NONE

## ABSTRACT:

Integrated Combustion Reactors (ICRs) and methods of making ICRs are described in which combustion chambers (or channels) are in direct thermal contact to reaction chambers for an endothermic reaction. Superior results were achieved for combustion chambers which contained a gap for free flow through the chamber. Particular reactor designs are also described. Processes of conducting reactions in integrated combustion reactors are described and results presented. Some of these processes are characterized by unexpected and superior results.

## RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. patent application Ser. Nos. 09/375,614 and 09/640,930, which are incorporated herein as if reproduced in full below. In accordance with 35 U.S.C. sect. 119(e), this application claims priority to U.S. Provisional Application No. 60/269,628, filed Feb. 16, 2001.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	EMC	Grand Cl
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----	----------

☐ 6. Document ID: US 6969506 B2

L3: Entry 6 of 11

File: USPT

Nov 29, 2005

US-PAT-NO: 6969506

DOCUMENT-IDENTIFIER: US 6969506 B2

TITLE: Methods of conducting simultaneous exothermic and endothermic reactions

DATE-ISSUED: November 29, 2005

## INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Tonkovich; Anna Lee	Marysville	OH		
Roberts; Gary L.	West Richland	WA		
Perry; Steven T.	Galloway	OH		
Fitzgerald; Sean P.	Columbus	OH		

## ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Battelle Memorial Institute	Richland	WA			02

APPL-NO: 10/076875 [PALM]

DATE FILED: February 14, 2002

## PARENT-CASE:

RELATED APPLICATIONS This application is a continuation-in-part of U.S. patent application Ser. No. 09/375,614 filed Aug. 17, 1999, now U.S. Pat. No. 6,488,838

and Ser. No. 09/640,903, filed Aug. 17, 2000 now U.S. Pat. No. 6,680,044, which are incorporated herein as if reproduced in full below. In accordance with 35 U.S.C. sect. 119(e), this application claims priority to U.S. Provisional Application No. 60/269,628, filed Feb. 16, 2001.

INT-CL: [07] C01 B 3/26

US-CL-ISSUED: 423/652; 252/373, 423/418.2, 423/656, 423/659

US-CL-CURRENT: 423/652; 252/373, 423/418.2, 423/656, 423/659

FIELD-OF-SEARCH: 252/373, 423/418.2, 423/652, 423/656, 423/659

PRIOR-ART-DISCLOSED:

#### U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
<u>4795618</u>	January 1989	Laumen	422/202
<u>5047381</u>	September 1991	Beebe	502/304
<u>5270127</u>	December 1993	Koga et al.	429/17
<u>5366719</u>	November 1994	van Wingerden et al.	423/659
<u>5403184</u>	April 1995	Hosaka et al.	431/170
<u>5518697</u>	May 1996	Dalla Betta et al.	422/173
<u>5565009</u>	October 1996	Ruhl et al.	48/197
<u>5609834</u>	March 1997	Hamada et al.	422/196
<u>5811062</u>	September 1998	Wegeng et al.	422/129
<u>5858314</u>	January 1999	Hsu et al.	422/211
<u>6040266</u>	March 2000	Fay et al.	502/439
<u>6056932</u>	May 2000	von Hippel et al.	423/376
<u>6117578</u>	September 2000	Lesieur	429/19
<u>6159358</u>	December 2000	Mulvaney et al.	208/46
<u>6165633</u>	December 2000	Negishi	429/17
<u>6168765</u>	January 2001	Romatier et al.	422/200
<u>6180846</u>	January 2001	Dandekar et al.	585/443
<u>6190624</u>	February 2001	Romatier	422/200
<u>6193501</u>	February 2001	Masel et al.	431/170
<u>6200536</u>	March 2001	Tonkovich et al.	422/177
<u>6228341</u>	May 2001	Hebert et al.	423/352
<u>6241875</u>	June 2001	Gough	208/106
<u>6274101</u>	August 2001	Sechrist	422/198
<u>6488838</u>	December 2002	Tonkovich et al.	208/108
<u>6616909</u>	September 2003	Tonkovich et al.	423/648.1
<u>2002/0106596</u>	August 2002	Hermann et al.	431/12
<u>2002/0168308</u>	November 2002	Loffler et al.	422/211

#### FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	CLASS
----------------	-----------	---------	-------



19841993	March 2000	DE
0848990	June 1998	EP
0885653	December 1998	EP
1031375	February 2000	EP
1123735	February 2001	EP
1123734	August 2001	EP
0869842	October 2001	EP
2353801	March 2001	GB
6111838	April 1994	JP
WO 96/32188	October 1996	WO
WO 00/06295	February 2000	WO
WO 01/10773	February 2001	WO
WO 01/12312	February 2001	WO
WO 01/54804	August 2001	WO
WO 01/54805	August 2001	WO
WO 01/54806	August 2001	WO
WO 01/89681	November 2001	WO

## OTHER PUBLICATIONS

Twigg et al., "Metal and Coated-Metal Catalysts," Chapter 3, pp. 59-89.

Kusakabe et al., "Development of a Microchannel Catalytic Reactor System," Korean J. Chem. Eng. 18(3), 271-276 (2001).

Cunha et al., "Modeling the integration of compact plate steam reformer in a fuel cell system," J Power Sources 86 (2000) 515-522.

Ismagilov et al., "Development and Study of metal foam heat-exchanging tubular reactor: Catalytic combustion of methane combined with methane steam reforming," Studies in Surface Science and Catalysis, pp. 2759-2764 (2000).

Polman et al., "Novel Compact steam reformer for fuel cells with heat generation by catalytic combustion augmented by induction heating," Catalysis Today pp. 347-351 (1999).

Arakawa et al., "Nonadiabatic developments lower process temperatures while improving reaction rates," Hydrocarbon Processing, (Mar. 1998).

Leonov et al., "Monolithic Catalyst Supports With Foam Structure," React. Kinet. Catal. Lett., 259-267 (1997).

Franz et al., "New Operating Regimes and Applications Feasible with Microreactors," in Process Mini: Second International Conf. On Microtechnology, 33-38 (1998).

Mulder et al., "Catalytic Combustion in a Sintered Metal Reactor with Integrated Heat Exchanger," Applied Thermal Engineering, 825-836 (1997).

Adris et al., "On the Reported Attempts to Radically Improve the Performance of the Steam Methane Reforming Reactor," Can. J. Of Chem Eng., 177-185 (1996).

Charlesworth, "Combustion and steam reforming of methane on thin layer catalysts for use in catalytic plate reactors," IMechE, 85-89 (1995).

ART-UNIT: 1754

PRIMARY-EXAMINER: Silverman; Stanley S.

ASSISTANT-EXAMINER: Medina; Maribel

ATTY-AGENT-FIRM: Rosenberg; Frank Harrington; Todd J.

ABSTRACT:

Integrated Combustion Reactors (ICRs) and methods of making ICRs are described in which combustion chambers (or channels) are in direct thermal contact to reaction chambers for an endothermic reaction. Superior results were achieved for combustion chambers which contained a gap for free flow through the chamber. Particular reactor designs are also described. Processes of conducting reactions in integrated combustion reactors are described and results presented. Some of these processes are characterized by unexpected and superior results.

30 Claims, 33 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	DOC	Grand
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	-----	-------

☐ 7. Document ID: US 6902934 B1

L3: Entry 7 of 11

File: USPT

Jun 7, 2005

US-PAT-NO: 6902934

DOCUMENT-IDENTIFIER: US 6902934 B1

\*\* See image for Certificate of Correction \*\*

TITLE: Methods for identifying optimizing catalysts in parallel-flow microreactors

DATE-ISSUED: June 7, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bergh; H. Sam	San Francisco	CA		
Guan; Shenheng	San Jose	CA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Symyx Technologies, Inc.	Santa Clara	CA			02

APPL-NO: 09/728732 [PALM]

DATE FILED: November 28, 2000

PARENT-CASE:

This application is a divisional of Ser. No. 09/518,794, filed Mar. 3, 2000, now U.S. Pat. No. 6,749,814 which claims priority to commonly owned, co-pending U.S. patent application Ser. No. 60/122,704 filed Mar. 3, 1999 entitled "Chemical Processing Microsystems, Diffusion-Mixed Microreactors and Methods for Preparing and Using Same", which is hereby incorporated by reference for all purposes.

INT-CL: [07] G01 N 31/10

US-CL-ISSUED: 436/37; 422/130, 422/99, 422/100, 422/129

US-CL-CURRENT: 436/37; 422/100, 422/129, 422/130, 422/99

FIELD-OF-SEARCH: 422/99-104, 422/129-131, 436/43, 436/37

PRIOR-ART-DISCLOSED:

## U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
<u>3431077</u>	March 1969	Danforth	23/253
<u>3797202</u>	March 1974	Neulander et al.	55/158
<u>4099923</u>	July 1978	Milberger	23/254
<u>4386505</u>	June 1983	Little	62/514R
<u>4392362</u>	July 1983	Little	62/514R
<u>4516632</u>	May 1985	Swift et al.	165/167
<u>4537217</u>	August 1985	Allen, Jr.	137/561A
<u>4636315</u>	January 1987	Allen, Jr.	210/656
<u>4832914</u>	May 1989	Tam et al.	422/130
<u>4999102</u>	March 1991	Cox et al.	210/137
<u>5016707</u>	May 1991	Nguyen	165/167
<u>5089232</u>	February 1992	May	422/83
<u>5145579</u>	September 1992	Eguchi et al.	210/198.2
<u>5209906</u>	May 1993	Watkins et al.	422/200
<u>5230866</u>	July 1993	Shartle et al.	422/103
<u>5296375</u>	March 1994	Kricka et al.	435/291
<u>5296775</u>	March 1994	Cronin et al.	310/309
<u>5304354</u>	April 1994	Finley et al.	422/196
<u>5354460</u>	October 1994	Kearney et al.	210/198.2
<u>5356756</u>	October 1994	Cavicchi et al.	430/315
<u>5385712</u>	January 1995	Sprunk	422/190
<u>5388635</u>	February 1995	Gruber et al.	165/80.4
<u>5534328</u>	July 1996	Ashmead et al.	428/166
<u>5580523</u>	December 1996	Bard	422/50
<u>5587128</u>	December 1996	Wilding et al.	422/50
<u>5593642</u>	January 1997	DeWitt et al.	422/131
<u>5603351</u>	February 1997	Cherukuri et al.	137/597
<u>5611214</u>	March 1997	Wegeng et al.	62/498
<u>5639423</u>	June 1997	Northrup et al.	122/50
<u>5658413</u>	August 1997	Kaltenbach et al.	156/272.8
<u>5658537</u>	August 1997	Dugan	422/191
<u>5690763</u>	November 1997	Ashmead et al.	156/60
<u>5699157</u>	December 1997	Parce	356/344
<u>5776359</u>	July 1998	Schultz et al.	252/62.51
<u>5811062</u>	September 1998	Wegeng et al.	422/129
<u>5842787</u>	December 1998	Kopf-Sill et al.	366/340
<u>5843385</u>	December 1998	Dugan	422/191
<u>5846396</u>	December 1998	Zanzucchi et al.	204/601
<u>5852495</u>	December 1998	Parce	356/344
<u>5858195</u>	January 1999	Ramsey	204/601
<u>5869004</u>	February 1999	Parce et al.	422/100
<u>5872010</u>	February 1999	Karger et al.	436/173
<u>5908552</u>	June 1999	Dittmann et al.	210/198.2
<u>5938333</u>	August 1999	Kearney	366/336

<u>5942443</u>	August 1999	Parce et al.	436/514
<u>5948227</u>	September 1999	Dubrow	204/455
<u>5955028</u>	September 1999	Chow	422/63
<u>5957579</u>	September 1999	Kopf-Sill et al.	366/340
<u>5965001</u>	October 1999	Chow et al.	204/600
<u>5965410</u>	October 1999	Chow et al.	435/91.2
<u>5976336</u>	November 1999	Dubrow et al.	204/453
<u>5989402</u>	November 1999	Chow et al.	204/601
<u>6001229</u>	December 1999	Ramsey	204/451
<u>6004515</u>	December 1999	Parce et al.	422/100
<u>6010607</u>	January 2000	Ramsey	204/435
<u>6010608</u>	January 2000	Ramsey	204/453
<u>6042709</u>	March 2000	Parce et al.	204/453
<u>6042710</u>	March 2000	Dubrow	204/454
<u>6046056</u>	April 2000	Parce et al.	436/514
<u>6068684</u>	May 2000	Overton	96/104
<u>6068752</u>	May 2000	Dubrow et al.	204/604
<u>6071478</u>	June 2000	Chow	422/81
<u>6074725</u>	June 2000	Kennedy	428/188
<u>6087180</u>	July 2000	Gleaves	436/37
<u>6100541</u>	August 2000	Nagle et al.	250/573
<u>6123798</u>	September 2000	Gandhi et al.	156/292
<u>6132685</u>	October 2000	Kercso et al.	422/104
<u>6190624</u>	February 2001	Romatier	422/200
<u>6319719</u>	November 2001	Bhullar et al.	436/70
<u>6333019</u>	December 2001	Coppens	423/659
<u>6409072</u>	June 2002	Breuer et al.	228/111.5

## FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	CLASS
196 32 779	February 1998	DE	
198 05 719	August 1999	DE	
198 06 848	August 1999	DE	
198 09 477	September 1999	DE	
0 870 541	October 1998	EP	
971 225	January 2000	EP	
0 870 541	November 2001	EP	
2 327 754	February 1999	GB	
WO 96/15576	May 1996	WO	
WO 96/35810	November 1996	WO	
WO 97/32208	September 1997	WO	
WO 98/07206	February 1998	WO	
WO 98/14268	April 1998	WO	
WO 98/16949	April 1998	WO	
WO 98/56956	December 1998	WO	

WO 99/10221	January 1999	WO
WO 99/19724	April 1999	WO
WO 99/30817	June 1999	WO
WO 99/34205	July 1999	WO
WO 99/41005	August 1999	WO
WO 99/43432	September 1999	WO
WO 99/48599	September 1999	WO
WO 99/59716	November 1999	WO
WO 98/64160	December 1999	WO
WO 99/64836	December 1999	WO
WO 00/07026	February 2000	WO
WO 00/14529	March 2000	WO
WO 00/21666	April 2000	WO
WO 00/22424	April 2000	WO
WO 00/32308	June 2000	WO
WO 00/32512	June 2000	WO
WO 0042212	July 2000	WO
WO 00/43766	July 2000	WO
WO 00/45172	August 2000	WO
WO 00/46594	August 2000	WO
WO 00/50172	August 2000	WO
WO 01/12327	February 2001	WO

## OTHER PUBLICATIONS

Nauman, E. Bruce. Chemical Reactor Design, Optimization, and Scaleup.

Jackel, K.P., "Microtechnology: Application Opportunities in the Chemical Industry" DEHEMA Monographs, vol. 132, VCH Verlagsgesellschaft 1996, pp. 29-50.

Ackelid, Ulf, et al. "Kinetic Studies of Diffusion Limited Gas-Surface Reactions By Spatially Resolved Gas Sampling: Reaction Rates and Sticking Coefficients in the H.sub.2 + O.sub.2 Reaction on Pt" Linkoping Studies in Science and Technology, Dissertations No. 392, 1995, pp. 122-133.

Zech et al., "Simultaneous Screening of Catalysts in Microchannels: Methodology and Experimental Setup" 00-00-1998, pp. 260-266 (XP-001006374).

Randhava, Ravi et al. "Advanced Configurations For Catalyst Research" Chemical Engineering Progress, vol. 70, No. 11 Nov. 1983, pp. 52-58.

Sie, S.T. "Reducing the Scale in Catalytic Process Research: Cost Savings" I 2 Procestechologie v. 7(3) 1991 IPRTEZ (Transaction).

Rodemerck, Uwe, et al. "Parallel Synthesis and Testing Systems of Heterogeneous Catalysts".

Mirth, Gabriele et al. "Design and Application of a New Reactor for in Situ Infrared Spectroscopic Investigations of Heterogeneously Catalyzed Reactions" 1369 Applied Spectroscopy, 48(1994) Feb., No. 2, pp. 194-197.

G.M. Greenway, S.J. Haswell, D.O. Morgan, et al., "The Use of a Novel Microreactor for High Throughtput Continuous Flow Organic Synthesis," Sensors and Actuators B-Chemical, 2000, 63, p. 153.

Burns et al., "Development of a Microreactor for Chemical Production," AIChE 2.sup.nd International Conference on Microreaction Technology, pp. 39-44 (1998).

Cooke, "Decreasing Gas Chromatography Analysis Times using a Multicapillary Column," Abs. 403P, Book of Abstracts, PittCon'96 (1996).

Ehrfeld et al., "Potentials and Realizations of Microreactors," DEHEMA Monographs vol. 132, pp. 1-28 (1995).

Hanak et al., "Optimization Studies of Materials in Hydrogenated Amorphous Silicon

Solar Cells," Photovoltaic Solar Energy Conference, Berlin (1979).  
Honick et al., "Heterogeneously Catalyzed Reactions in a Microreactor," DECHEMA Monographs vol. 132, pp. 93-107 (1995).  
Johansson et al., "Nanofabrication of Model Catalysts and Simulations of their Reaction Kinetics," J. Vac. Sci. Technol., 17:1 (Jan./Feb. 1999).  
Lowe et al., "Microreactor Concepts for Heterogeneous Gas Phase Reactions," AIChE 2.sup.nd International Conference on Microreaction Technology, pp. 63-73 (1998).  
Matiosz et al., "Microsectioned Electrochemical Reactors for Selective Partial Oxidation," AIChE 2.sup.nd International Conference on Microreaction Technology, pp. 54-59 (1998).  
S.M. Sze, "Semiconductor Sensors," Chap. 2, pp. 17-96, John Wiley & Sons, Inc. (1994).  
Srinivasan et al., "Micromachined Reactors for Catalytic Partial Oxidation Reactions," AIChE Journal, vol. 43, No. 11, pp. 3059-3069 (1997).  
Tonkovich et al., "The Catalytic Partial Oxidation of Methane in a Microchemical Reactor," AIChE 2 .sup.nd International Conference on Microreaction Technology, pp. 45-53 (1998).  
van Dover et al., "Discovery of a Useful Thin-Film Dielectric Using a Composition-Spread Approach," Nature, vol. 392, No. 12, pp. 162-164 (1998).  
Bunshah, "Handbook of Deposition Technologies for Films and Coatings," 2.sup.nd Ed., Noyes Publications (1994).

ART-UNIT: 1743

PRIMARY-EXAMINER: Alexander; Lyle A.

ABSTRACT:

A chemical processing microsystem useful for identifying and optimizing, materials (e.g., catalysts) that enhance chemical processes or for characterizing and/or optimizing chemical processes is disclosed. The chemical processing microsystem comprises a plurality of microreactors 600 and, in a preferred embodiment, a plurality of microseparators 900 integral with the chemical processing microsystem 10. The microreactors 600 are preferably diffusion-mixed microreactors formed in a plurality of laminae that include a modular, interchangeable candidate-material array 100. The material array 100 comprises a plurality of different candidate materials (e.g., catalysts), preferably arranged at separate, individually addressable portions of a substrate (e.g., wafer). The microseparators 900 are similarly formed in a plurality of laminae that include a modular, interchangeable adsorbent array 700.

54 Claims, 88 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	FIGS	Draw D
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	--------

☐ 8. Document ID: US 6890493 B1

L3: Entry 8 of 11

File: USPT

May 10, 2005

US-PAT-NO: 6890493

DOCUMENT-IDENTIFIER: US 6890493 B1

TITLE: Methods and apparatus for fluid distribution in microfluidic systems

DATE-ISSUED: May 10, 2005

## INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bergh; H. Sam	San Francisco	CA		
Guan; Shenheng	San Jose	CA		

## ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Symyx Technologies, Inc.	Santa Clara	CA			02

APPL-NO: 09/728263 [PALM]  
DATE FILED: November 28, 2000

## PARENT-CASE:

This application is a divisional application of co-pending U.S. patent application Ser. No. 09/518,794 filed Mar. 3, 2000, which itself claims priority to commonly owned, co-pending U.S. patent application Ser. No. 60/122,704 filed Mar. 3, 1999 entitled "Chemical Processing Microsystems, Diffusion-Mixed Microreactors and Methods for Preparing and Using Same", which is hereby incorporated by reference for all purposes.

INT-CL: [07] B01 J 19/00

US-CL-ISSUED: 422/130; 422/129, 422/99, 422/102, 436/52, 436/53, 436/180, 436/37, 137/884

US-CL-CURRENT: 422/130; 137/884, 422/102, 422/129, 422/99, 436/180, 436/37, 436/52, 436/53

FIELD-OF-SEARCH: 422/99-104, 422/129-131, 436/180, 436/52, 436/53, 436/37, 137/884

## PRIOR-ART-DISCLOSED:

## U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
<u>3431077</u>	March 1969	Danforth	23/253
<u>3797202</u>	March 1974	Neulander et al.	55/158
<u>3966420</u>	June 1976	Pegels et al.	23/288R
<u>4099923</u>	July 1978	Milberger	23/254
<u>4386505</u>	June 1983	Little	62/514R
<u>4392362</u>	July 1983	Little	62/514R
<u>4516632</u>	May 1985	Swift et al.	165/167
<u>4537217</u>	August 1985	Allen, Jr.	137/561A
<u>4636315</u>	January 1987	Allen, Jr.	210/656
<u>4820495</u>	April 1989	Vu et al.	422/148
<u>4832914</u>	May 1989	Tam et al.	422/130
<u>4921919</u>	May 1990	Lin et al.	526/88
<u>4999102</u>	March 1991	Cox et al.	210/137
<u>5016707</u>	May 1991	Nguyen	165/167
<u>5079205</u>	January 1992	Canich	502/117

<u>5089232</u>	February 1992	May	422/83
<u>5145579</u>	September 1992	Eguchi et al.	210/198.2
<u>5209906</u>	May 1993	Watkins et al.	422/200
<u>5230866</u>	July 1993	Shartle et al.	422/103
<u>5288644</u>	February 1994	Beavis et al.	436/94
<u>5296375</u>	March 1994	Kricka et al.	435/2
<u>5296775</u>	March 1994	Cronin et al.	310/309
<u>5304354</u>	April 1994	Finley et al.	422/196
<u>5354460</u>	October 1994	Kearney et al.	210/198.2
<u>5356756</u>	October 1994	Cavicchi et al.	430/315
<u>5385712</u>	January 1995	Sprunk	422/190
<u>5388635</u>	February 1995	Gruber et al.	165/80.4
<u>5498545</u>	March 1996	Vestal	436/47
<u>5534328</u>	July 1996	Ashmead et al.	428/166
<u>5580523</u>	December 1996	Bard	422/50
<u>5587128</u>	December 1996	Wilding et al.	422/50
<u>5593642</u>	January 1997	DeWitt et al.	422/131
<u>5603351</u>	February 1997	Cherukuri et al.	137/597
<u>5611214</u>	March 1997	Wegeng et al.	62/498
<u>5639423</u>	June 1997	Northrup et al.	122/50
<u>5658413</u>	August 1997	Kaltenbach et al.	156/272.8
<u>5658537</u>	August 1997	Dugan	422/191
<u>5690763</u>	November 1997	Ashmead et al.	156/60
<u>5699157</u>	December 1997	Parce	356/344
<u>5770860</u>	June 1998	Franzen	250/288
<u>5776359</u>	July 1998	Schultz et al.	252/62.51
<u>5811062</u>	September 1998	Wegeng et al.	422/129
<u>5842787</u>	December 1998	Kopf-Sill et al.	366/340
<u>5843385</u>	December 1998	Dugan	422/191
<u>5846396</u>	December 1998	Zanzucchi et al.	204/601
<u>5852495</u>	December 1998	Parce	356/344
<u>5858195</u>	January 1999	Ramsey	204/601
<u>5869004</u>	February 1999	Parce et al.	422/100
<u>5872010</u>	February 1999	Karger et al.	436/173
<u>5908552</u>	June 1999	Dittmann et al.	210/198.2
<u>5935277</u>	August 1999	Autenrieth et al.	48/127.9
<u>5938333</u>	August 1999	Kearney	366/336
<u>5942443</u>	August 1999	Parce et al.	436/514
<u>5948227</u>	September 1999	Dubrow	204/455
<u>5955028</u>	September 1999	Chow	422/63
<u>5957579</u>	September 1999	Kopf-Sill et al.	366/340
<u>5959297</u>	September 1999	Weinberg et al.	250/288
<u>5965001</u>	October 1999	Chow et al.	204/600
<u>5965410</u>	October 1999	Chow et al.	435/91.2
<u>5976336</u>	November 1999	Dubrow et al.	204/453
<u>5989402</u>	November 1999	Chow et al.	204/601
<u>6001229</u>	December 1999	Ramsey	204/451



<u>6004515</u>	December 1999	Parce et al.	422/100
<u>6010607</u>	January 2000	Ramsey	204/435
<u>6010608</u>	January 2000	Ramsey	204/453
<u>6042709</u>	March 2000	Parce et al.	204/453
<u>6042710</u>	March 2000	Dubrow	204/454
<u>6046056</u>	April 2000	Parce et al.	436/514
<u>6068684</u>	May 2000	Overton	96/104
<u>6068752</u>	May 2000	Dubrow et al.	204/604
<u>6071478</u>	June 2000	Chow	422/81
<u>6074725</u>	June 2000	Kennedy	428/188
<u>6087180</u>	July 2000	Gleaves	436/37
<u>6087181</u>	July 2000	Cong	436/37
<u>6100541</u>	August 2000	Nagle et al.	250/573
<u>6103199</u>	August 2000	Bjornson et al.	422/100
<u>6123798</u>	September 2000	Gandhi et al.	156/292
<u>6132685</u>	October 2000	Kercso et al.	422/104
<u>6143152</u>	November 2000	Simpson et al.	204/451
<u>6149882</u>	November 2000	Guan et al.	422/211
<u>6221654</u>	April 2001	Quake et al.	435/287.3
<u>6287872</u>	September 2001	Schurenberg et al.	436/181
<u>6319719</u>	November 2001	Bhullar et al.	436/70
<u>6333019</u>	December 2001	Coppens	423/659
<u>6350617</u>	February 2002	Hindsgaul et al.	436/173
<u>6409072</u>	June 2002	Breuer et al.	228/111.5
<u>6426226</u>	July 2002	Senkan	436/37
<u>6485692</u>	November 2002	Freitag et al.	422/130
<u>2002/0042140</u>	April 2002	Hagemeyer et al.	436/34

## FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	CLASS
196 32 779	August 1996	DE	
198 05 719	February 1998	DE	
198 06 848	February 1998	DE	
198 55 894	December 1998	DE	
198 09 477	September 1999	DE	
0 870 541	October 1998	EP	
971 225	January 2000	EP	
2 327 754	February 1999	GB	
WO 96/15576	May 1996	WO	
WO 96/35810	November 1996	WO	
WO 97/32208	September 1997	WO	
WO 98/07206	February 1998	WO	
WO 98/16949	April 1998	WO	
WO 98/56956	December 1998	WO	
WO 99/10221	January 1999	WO	

WO 99/19724	April 1999	WO
WO 99/30817	June 1999	WO
WO 99/34205	July 1999	WO
WO 99/41005	August 1999	WO
WO 99/43432	September 1999	WO
WO 99/48599	September 1999	WO
WO 99/59716	November 1999	WO
WO 99/64160	December 1999	WO
WO 99/64836	December 1999	WO
WO 00/07026	February 2000	WO
WO 00/14529	March 2000	WO
WO 00/21666	April 2000	WO
WO 00/22424	April 2000	WO
WO 00/32308	June 2000	WO
WO 00/32512	June 2000	WO
WO 0042212	July 2000	WO
WO 00/43766	July 2000	WO
WO 00/45172	August 2000	WO
WO 00/46594	August 2000	WO
WO 00/50172	August 2000	WO
WO 01/12327	February 2001	WO

## OTHER PUBLICATIONS

G.M. Greenway, S.J. Haswell, D.O. Morgan, et al., "The Use of a Novel Microreactor for High Throughput Continuous Flow Organic Synthesis," *Sensors and Actuators B-Chemical*, 2000, 63, p. 153.

Burns et al., "Development of a Microreactor for Chemical Production," *AlChE 2.sup.nd International Conference on Microreaction Technology*, pp. 39-44 (1998).

Cooke, "Decreasing Gas Chromatography Analysis Times using a Multicapillary Column," Abs. 403P, *Book of Abstracts, PittCon' '96* (1996).

Ehrfeld et al., "Potentials and Realizations of Microreactors," *DECHEMA Monographs* vol. 132, pp. 1-28 (1995).

Hanak et al., "Optimization Studies of Materials in Hydrogenated Amorphous Silicon Solar Cells," *Photovoltaic Solar Energy Conference, Berlin* (1979).

Honicke et al., "Heterogeneously Catalyzed Reactions in a Microreactor," *DECHEMA Monographs* vol. 132, pp. 93-107 (1995).

Johansson et al., "Nanofabrication of Model Catalysts and Simulations of their Reaction Kinetics," *J. Vac. Sci. Technol.*, 17:1 (Jan./Feb. 1999).

Lowe et al., "Microreactor Concepts for Heterogeneous Gas Phase Reactions," *AlChE 2.sup.nd International Conference on Microreaction Technology*, pp. 63-73 (1998).

Matlosz et al., "Microsectioned Electrochemical Reactors for Selective Partial Oxidation," *AlChE 2.sup.nd International Conference on Microreaction Technology*, pp. 54-59 (1998).

S.M. Sze, "Semiconductor Sensors," Chap. 2, pp. 17-96, *John Wiley & Sons, Inc.* (1994).

Srinivasan et al., "Micromachined Reactors for Catalytic Partial Oxidation Reactions," *AlChE Journal*, vol. 43, No. 11, pp. 3059-3069 (1997).

Tonkovich et al., "The Catalytic Partial Oxidation of Methane in a Microchemical Reactor," *AlChE 2.sup.nd International Conference on Microreaction Technology*, pp. 45-53 (1998).

van Dover et al., "Discovery of a Useful Thin-Film Dielectric Using a Composition-Spread Approach," *Nature*, vol. 392, No. 12, pp. 162-164 (1998).

Bunshah, "Handbook of Deposition Technologies for Films and Coatings," 2.sup.nd

Ed., Noyes Publications (1994).

Jackel, K.P., "Microtechnology: Application Opportunities in the Chemical Industry" DECHEMA Monographs, vol. 132 VCH Verlagsgesellschaft 1996, pp. 29-50.

Ackelid, Ulf, et al. "Kinetic Studies of Diffusion Limited Gas-Surface Reactions by Spatially Resolved Gas Sampling: Reaction Rates and Sticking Coefficients in the H.sub.2 +O.sub.2 Reaction on Pt" Linkoping Studies in Science and Technology, Dissertations No. 392, 1995, pp. 122-133.

Zech et al., "Simultaneous Screening of Catalysts in Microchannels: Methodology and Experimental Setup" 00-00-1998, pp. 260-266 (XP-001006374).

Randhava, Ravi et al. "Advanced Configurations for Catalyst Research" Chemical Engineering Progress, vol. 70, No. 11 Nov. 1983, pp. 52-58.

Sie, S.T. "Reducing the Scale in Catalytic Process Research: Cost Savings" I 2 Procestechologie v. 7(3) 1991 IPRTEZ (Translation).

Rodemerck, Uwe, et al., "Parallel Synthesis and Testing Systems of Heterogeneous Catalysts".

Mirth, Gabriele et al. "Design and Application of a New Reactor for in Situ Infrared Spectroscopic Investigations of Heterogeneously Catalyzed Reactions" 1369 Applied Spectroscopy, 48(1994) Feb., No. 2, pp. 194-197.

ART-UNIT: 1743

PRIMARY-EXAMINER: Warden; Jill

ASSISTANT-EXAMINER: Quan; Elizabeth

ABSTRACT:

A chemical processing microsystem useful for identifying and optimizing materials (e.g., catalysts) that enhance chemical processes or for characterizing and/or optimizing chemical processes is disclosed. The chemical processing microsystem comprises a plurality of microreactors 600 and, in a preferred embodiment, a plurality of microseparators 900 integral with the chemical processing microsystem 10. The microreactors 600 are preferably diffusion-mixed microreactors formed in a plurality of laminae that include a modular, interchangeable candidate-material array 100. The material array 100 comprises a plurality of different candidate materials (e.g., catalysts), preferably arranged at separate, individually addressable portions of a substrate (e.g., wafer). The microseparators 900 are similarly formed in a plurality of laminae that include a modular, interchangeable adsorbent array 700. The adsorbent array 700 comprises one or more adsorbents, preferably arranged at separate, individually addressable portions of a substrate to spatially correspond to the plurality of different candidate materials. Modular microfluidic distribution systems are also disclosed. The chemical processing microsystem can be integrated into a material evaluation system that enables a comprehensive combinatorial material science research program.

15 Claims, 72 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference	Claims	ExmC	Exam D.
------	-------	----------	-------	--------	----------------	------	-----------	--------	------	---------

☐ 9. Document ID: US 6749814 B1

L3: Entry 9 of 11

File: USPT

Jun 15, 2004

US-PAT-NO: 6749814

DOCUMENT-IDENTIFIER: US 6749814 B1

\*\* See image for Certificate of Correction \*\*

TITLE: Chemical processing microsystems comprising parallel flow microreactors and methods for using same

DATE-ISSUED: June 15, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bergh; H. Sam	San Francisco	CA		
Guan; Shenheng	San Jose	CA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Symyx Technologies, Inc.	Santa Clara	CA			02

APPL-NO: 09/518794 [PALM]

DATE FILED: March 3, 2000

PARENT-CASE:

This application claims priority to commonly owned, co-pending U.S. patent application Ser. No. 60/122,704 filed Mar. 3, 1999 entitled "Chemical Processing Microsystems, Diffusion-Mixed Microreactors and Methods for Preparing and Using same", which is hereby incorporated by reference for all purposes.

INT-CL: [07] B01 J 19/00, G01 N 31/00

US-CL-ISSUED: 422/130; 422/99, 422/100, 422/102, 422/129, 436/37

US-CL-CURRENT: 422/130; 422/100, 422/102, 422/129, 422/99, 436/37

FIELD-OF-SEARCH: 422/99-104, 422/129-131

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
<u>3431077</u>	March 1969	Danforth	23/253
<u>3797202</u>	March 1974	Neulander et al.	96/5
<u>3966420</u>	June 1976	Pegels et al.	23/288R
<u>4099923</u>	July 1978	Milberger	23/254
<u>4386505</u>	June 1983	Little	62/514R
<u>4392362</u>	July 1983	Little	62/514R
<u>4516632</u>	May 1985	Swift et al.	165/167
<u>4537217</u>	August 1985	Allen, Jr.	137/561
<u>4636315</u>	January 1987	Allen, Jr.	210/656
<u>4832914</u>	May 1989	Tam et al.	422/130
<u>4921919</u>	May 1990	Lin et al.	526/88
<u>5016707</u>	May 1991	Nguyen	165/167
<u>5079205</u>	January 1992	Canich	502/117
<u>5089232</u>	February 1992	May	422/83

<u>5145579</u>	September 1992	Eguchi et al.	210/198.2
<u>5209906</u>	May 1993	Watkins et al.	422/200
<u>5230866</u>	July 1993	Shartle et al.	422/103
<u>5288644</u>	February 1994	Beavis et al.	436/94
<u>5296375</u>	March 1994	Kricka et al.	435/291
<u>5296775</u>	March 1994	Cronin et al.	310/309
<u>5304354</u>	April 1994	Finley et al.	422/196
<u>5354460</u>	October 1994	Kearney et al.	210/198.2
<u>5356756</u>	October 1994	Cavicchi et al.	430/315
<u>5385712</u>	January 1995	Sprunk	422/190
<u>5388635</u>	February 1995	Gruber et al.	165/80.4
<u>5498545</u>	March 1996	Vestal	436/47
<u>5534328</u>	July 1996	Ashmead et al.	428/166
<u>5580523</u>	December 1996	Bard	422/50
<u>5587128</u>	December 1996	Wilding et al.	422/50
<u>5593642</u>	January 1997	DeWitt et al.	422/131
<u>5603351</u>	February 1997	Cherukuri et al.	137/597
<u>5611214</u>	March 1997	Wegeng et al.	62/498
<u>5639423</u>	June 1997	Northrup et al.	122/50
<u>5658413</u>	August 1997	Kaltenbach et al.	156/272.8
<u>5658537</u>	August 1997	Dugan	422/191
<u>5690763</u>	November 1997	Ashmead et al.	156/60
<u>5699157</u>	December 1997	Parce	356/344
<u>5770860</u>	June 1998	Franzen	250/288
<u>5776359</u>	July 1998	Schultz et al.	252/62.51
<u>5811062</u>	September 1998	Wegeng et al.	422/129
<u>5842787</u>	December 1998	Kopf-Sill et al.	366/340
<u>5843385</u>	December 1998	Dugan	422/191
<u>5846396</u>	December 1998	Zanzucchi et al.	204/601
<u>5852495</u>	December 1998	Parce	356/344
<u>5858195</u>	January 1999	Ramsey	204/601
<u>5869004</u>	February 1999	Parce et al.	422/100
<u>5872010</u>	February 1999	Karger et al.	436/173
<u>5908552</u>	June 1999	Dittmann et al.	210/198.2
<u>5935277</u>	August 1999	Autenrieth et al.	48/127.9
<u>5938333</u>	August 1999	Kearney	366/336
<u>5942443</u>	August 1999	Parce et al.	436/514
<u>5948227</u>	September 1999	Dubrow	204/455
<u>5955028</u>	September 1999	Chow	422/63
<u>5957579</u>	September 1999	Kopf-Sill et al.	366/340
<u>5959297</u>	September 1999	Weinberg et al.	250/288
<u>5965001</u>	October 1999	Chow et al.	204/600
<u>5965410</u>	October 1999	Chow et al.	435/91.2
<u>5976336</u>	November 1999	Dubrow et al.	204/453
<u>5989402</u>	November 1999	Chow et al.	204/601
<u>6001229</u>	December 1999	Ramsey	204/451
<u>6004515</u>	December 1999	Parce et al.	422/100

<u>6010607</u>	January 2000	Ramsey	204/435
<u>6010608</u>	January 2000	Ramsey	204/453
<u>6042709</u>	March 2000	Parce et al.	204/453
<u>6042710</u>	March 2000	Dubrow	204/454
<u>6046056</u>	April 2000	Parce et al.	436/514
<u>6068684</u>	May 2000	Overton	96/104
<u>6068752</u>	May 2000	Dubrow et al.	204/604
<u>6071478</u>	June 2000	Chow	422/81
<u>6074725</u>	June 2000	Kennedy	428/188
<u>6086740</u>	July 2000	Kennedy	204/601
<u>6087180</u>	July 2000	Gleaves	436/37
<u>6087181</u>	July 2000	Cong	436/37
<u>6100541</u>	August 2000	Nagle et al.	250/573
<u>6103199</u>	August 2000	Bjornson et al.	422/100
<u>6123798</u>	September 2000	Gandhi et al.	156/292
<u>6132685</u>	October 2000	Kercso et al.	422/104
<u>6149882</u>	November 2000	Guan et al.	422/211
<u>6287872</u>	September 2001	Schurenberg et al.	436/181
<u>6319719</u>	November 2001	Bhullar et al.	436/70
<u>6333019</u>	December 2001	Coppens	423/659
<u>6350617</u>	February 2002	Hindsgaul et al.	436/173
<u>6409072</u>	June 2002	Breuer et al.	228/111.5
<u>6426226</u>	July 2002	Senkan	436/37
<u>6485692</u>	November 2002	Frietag et al.	422/130
<u>2002/0042140</u>	April 2002	Hagemeyer et al.	436/34

## FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	CLASS
27 14 939	October 1978	DE	
234 941	February 1985	DE	
196 32 779	February 1998	DE	
198 05 719	August 1999	DE	
198 06 848	August 1999	DE	
198 09 477	September 1999	DE	
198 55 894	June 2000	DE	
0 870 541	October 1998	EP	
971 225	January 2000	EP	
2 327 754	February 1999	GB	
WO 96/15576	May 1996	WO	
WO 96/35810	November 1996	WO	
WO 97/32208	September 1997	WO	
WO 98/07206	February 1998	WO	
WO 98/14268	April 1998	WO	
WO 98/16949	April 1998	WO	
WO 98/56956	December 1998	WO	

WO 99/10221	January 1999	WO
WO 99/19724	April 1999	WO
WO 99/30817	June 1999	WO
WO 99/34205	July 1999	WO
WO 99/41005	August 1999	WO
WO 99/43432	September 1999	WO
WO 99/48599	September 1999	WO
WO 99/59716	November 1999	WO
WO 99/64160	December 1999	WO
WO 99/64836	December 1999	WO
WO 00/07026	February 2000	WO
WO 00/14529	March 2000	WO
WO 00/21666	April 2000	WO
WO 00/22424	April 2000	WO
WO 00/32308	June 2000	WO
WO 00/32512	June 2000	WO
WO 0042212	July 2000	WO
WO 00/43766	July 2000	WO
WO 00/45172	August 2000	WO
WO 00/46594	August 2000	WO
WO 00/50172	August 2000	WO
WO 01/12327	February 2001	WO

## OTHER PUBLICATIONS

G.M. Greenway, S.J. Haswell, D.O. Morgan, et al., "The Use of a Novel Microreactor for High Throughput Continuous Flow Organic Synthesis," *Sensors and Actuators B-Chemical*, 2000, 63, p. 153.

Burns et al., "Development of a Microreactor for Chemical Production," *AlChE 2.sup.nd International Conference on Microreaction Technology*, pp. 39-44 (1998).

Cooke, "Decreasing Gas Chromatography Analysis Times Using a Multicapillary Column," Abs. 403P, *Book of Abstracts, PittCon' '96* (1996).

Ehrfeld et al., "Potentials and Realizations of Microreactors," *DECHEMA Monographs* vol. 132, pp. 1-28 (1995).

Hanak et al., "Optimization Studies of Materials in Hydrogenated Amorphous Silicon Solar Cells," *Photovoltaic Solar Energy Conference*, Berlin (1979).

Honick et al., "Heterogeneously Catalyzed Reactions in a Microreactor," *DECHEMA Monographs* vol. 132, pp. 93-107 (1995).

Johansson et al., "Nanofabrication of Model Catalysts and Simulations of their Reaction Kinetics," *J. Vac. Sci. Technol.*, 17:1 (Jan./Feb. 1999).

Lowe et al., "Microreactor Concepts for Heterogeneous Gas Phase Reactions," *AlChE 2.sup.nd International Conference on Microreaction Technology*, pp. 63-73 (1998).

Matlosz et al., "Microsectioned Electrochemical Reactors for Selective Partial Oxidation," *AlChE 2.sup.nd International Conference on Microreaction Technology*, pp. 54-59 (1998).

S.M. Sze, "Semiconductor Sensors," Chap. 2, pp. 17-96, John Wiley & Sons, Inc. (1994).

Srinivasan et al., "Micromachined Reactors for Catalytic Partial Oxidation Reactions," *AlChE Journal*, vol. 43, No. 11, pp. 3059-3069 (1997).

Tonkovich et al., "The Catalytic Partial Oxidation of Methane in a Microchemical Reactor," *AlChE 2.sup.nd International Conference on Microreaction Technology*, pp. 45-53 (1998).

van Dover et al., "Discovery of a Useful Thin-Film Dielectric Using a Composition-

Spread Approach," Nature, vol. 392, No. 12, pp. 162-164 (1998).  
Bunshah, "Handbook of Deposition Technologies for Films and Coatings," 2.sup.nd Ed., Noyes Publications (1994).  
Jackel, K.P., "Microtechnology: Application Opportunities in the Chemical Industry" DECHEMA Monographs, vol. 132, VCH Verlagsgesellschaft 1996, pp. 29-50.  
Ackelid, Ulf, et al. "Kinetic Studies of Diffusion Limited Gas-Surface Reactions By Spatially Resolved Gas Sampling: Reaction Rates and Sticking Coefficients in the H.sub.2 +O.sub.2 Reaction on Pt" Linkoping Studies In Science and Technology, Dissertations No. 392, 1995, pp. 122-133.  
Zech et al., "Simultaneous Screening of Catalysts in Microchannels: Methodology and Experimental Setup" 00-00-1998, pp. 260-266 (XP-001006374).  
Randhava, Ravi et al. "Advanced Configurations For Catalyst Research" Chemical Engineering Progress, vol. 70, No. 11 Nov. 1983, pp. 52-58.  
Sie, S.T. "Reducing the Scale in Catalytic Process Research: Cost Savings" I 2 Procestechologie v. 7(3) 1991 Iprtez (Translation).  
Rodemerck, Uwe, et al. "Parallel Synthesis and Testing Systems of Heterogeneous Catalysts".  
Mirth, Gabriele et al. "Design and Application of a New Reactor for in Situ Infrared Spectroscopic Investigations of Heterogeneously Catalyzed Reactions" 1369 Applied Spectroscopy, 48(1994) Feb., No. 2, pp. 194-197.  
Van den Berg et al., "Modular Concept for Miniature Chemical Systems," DECHEMA Monographs vol. 132 (1995), pp. 109-123.

ART-UNIT: 1743

PRIMARY-EXAMINER: Warden; Jill

ASSISTANT-EXAMINER: Quan; Elizabeth

ABSTRACT:

A chemical processing microsystem useful for identifying and optimizing materials (e.g., catalysts) that enhance chemical processes or for characterizing and/or optimizing chemical processes is disclosed. The chemical processing microsystem comprises a plurality of microreactors 600 and, in a preferred embodiment, a plurality of microseparators 900 integral with the chemical processing microsystem 10. The microreactors 600 are preferably diffusion-mixed microreactors formed in a plurality of laminae that include a modular, interchangeable candidate-material array 100. The material array 100 comprises a plurality of different candidate materials (e.g., catalysts), preferably arranged at separate, individually addressable portions of a substrate (e.g., wafer). The microseparators 900 are similarly formed in a plurality of laminae that include a modular, interchangeable adsorbent array 700. The adsorbent array 700 comprises one or more adsorbents, preferably arranged at separate, individually, addressable portions of a substrate to spatially correspond to the plurality of different candidate materials. Modular microfluidic distribution systems are also disclosed. The chemical processing microsystem can be integrated into a material evaluation system that enables a comprehensive combinatorial material science research program.

142 Claims, 88 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference	Claims	MMC	Grand
------	-------	----------	-------	--------	----------------	------	-----------	--------	-----	-------

☐ 10. Document ID: US 6737026 B1



L3: Entry 10 of 11

File: USPT

May 18, 2004

US-PAT-NO: 6737026

DOCUMENT-IDENTIFIER: US 6737026 B1

**\*\* See image for Certificate of Correction \*\***

TITLE: Methods for identifying and optimizing materials in microfluidic systems

DATE-ISSUED: May 18, 2004

## INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Bergh; H. Sam	San Francisco	CA		
Guan; Shenheng	San Jose	CA		

## ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Symyx Technologies, Inc.	Santa Clara	CA			02

APPL-NO: 09/728209 [PALM]

DATE FILED: November 28, 2000

## PARENT-CASE:

This application claims is a divisional application of copending U.S. patent application Ser. No. 09/518,794 filed Mar. 3, 2000, which itself priority to commonly owned, co-pending U.S. patent application Ser. No. 60/122,704 filed Mar. 3, 1999 entitled "Chemical Processing Microsystems, Diffusion-Mixed Microreactors and Methods for Preparing and Using Same", which is hereby incorporated by reference for all purposes.

INT-CL: [07] B01 J 19/00, G01 N 31/10

US-CL-ISSUED: 422/130; 422/129, 422/99, 422/102, 422/100, 436/37

US-CL-CURRENT: 422/130; 422/100; 422/102, 422/129, 422/99, 436/37

FIELD-OF-SEARCH: 422/99-104, 422/129-131, 436/37

## PRIOR-ART-DISCLOSED:

## U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
<u>3431077</u>	March 1969	Danforth	23/253
<u>3797202</u>	March 1974	Neulander et al.	55/158
<u>3966420</u>	June 1976	Pegels et al.	422/191
<u>4099923</u>	July 1978	Milberger	23/254
<u>4386505</u>	June 1983	Little	62/514R
<u>4392362</u>	July 1983	Little	62/514R
<u>4516632</u>	May 1985	Swift et al.	165/167
<u>4537217</u>	August 1985	Allen, Jr.	137/561A
<u>4636315</u>	January 1987	Allen, Jr.	210/656

<u>4832914</u>	May 1989	Tam et al.	422/130
<u>4921919</u>	May 1990	Lin et al.	526/88
<u>4999102</u>	March 1991	Cox et al.	210/137
<u>5016707</u>	May 1991	Nguyen	165/167
<u>5079205</u>	January 1992	Canich	502/117
<u>5089232</u>	February 1992	May	422/83
<u>5145579</u>	September 1992	Eguchi et al.	210/198.2
<u>5209906</u>	May 1993	Watkins et al.	422/200
<u>5230866</u>	July 1993	Shartle et al.	422/103
<u>5288644</u>	February 1994	Beavis et al.	436/94
<u>5296375</u>	March 1994	Kricka et al.	435/2
<u>5296775</u>	March 1994	Cronin et al.	310/309
<u>5304354</u>	April 1994	Finley et al.	422/196
<u>5354460</u>	October 1994	Kearney et al.	210/198.2
<u>5356756</u>	October 1994	Cavicchi et al.	430/315
<u>5385712</u>	January 1995	Sprunk	422/190
<u>5388635</u>	February 1995	Gruber et al.	165/80.4
<u>5498545</u>	March 1996	Vestal	436/47
<u>5534328</u>	July 1996	Ashmead et al.	428/166
<u>5580523</u>	December 1996	Bard	422/50
<u>5587128</u>	December 1996	Wilding et al.	422/50
<u>5593642</u>	January 1997	DeWitt et al.	422/131
<u>5603351</u>	February 1997	Cherukuri et al.	137/597
<u>5611214</u>	March 1997	Wegeng et al.	62/498
<u>5639423</u>	June 1997	Northrup et al.	122/50
<u>5658413</u>	August 1997	Kaltenbach et al.	156/272.8
<u>5690763</u>	November 1997	Ashmead et al.	156/60
<u>5699157</u>	December 1997	Parce	356/344
<u>5770860</u>	June 1998	Franzen	250/288
<u>5776359</u>	July 1998	Schultz et al.	252/62.51
<u>5811062</u>	September 1998	Wegeng et al.	422/129
<u>5842787</u>	December 1998	Kopf-Sill et al.	366/340
<u>5843385</u>	December 1998	Dugan	422/191
<u>5846396</u>	December 1998	Zanzucchi et al.	204/601
<u>5852495</u>	December 1998	Parce	356/344
<u>5858195</u>	January 1999	Ramsey	204/601
<u>5869004</u>	February 1999	Parce et al.	422/100
<u>5872010</u>	February 1999	Karger et al.	436/173
<u>5908552</u>	June 1999	Dittmann et al.	210/198.2
<u>5935277</u>	August 1999	Autenreith et al.	48/127.9
<u>5938333</u>	August 1999	Kearney	366/336
<u>5942443</u>	August 1999	Parce et al.	436/514
<u>5948227</u>	September 1999	Dubrow	204/455
<u>5955028</u>	September 1999	Chow	422/63
<u>5957579</u>	September 1999	Kopf-Sill et al.	366/340
<u>5959297</u>	September 1999	Weinberg et al.	250/288
<u>5965001</u>	October 1999	Chow et al.	204/600

<u>5965410</u>	October 1999	Chow et al.	435/91.2
<u>5976336</u>	November 1999	Dubrow et al.	204/453
<u>5989402</u>	November 1999	Chow et al.	204/601
<u>6001229</u>	December 1999	Ramsey	204/451
<u>6004515</u>	December 1999	Parce et al.	422/100
<u>6010607</u>	January 2000	Ramsey	204/435
<u>6010608</u>	January 2000	Ramsey	204/453
<u>6042709</u>	March 2000	Parce et al.	204/453
<u>6042710</u>	March 2000	Dubrow	204/454
<u>6046056</u>	April 2000	Parce et al.	436/514
<u>6068684</u>	May 2000	Overton	96/104
<u>6068752</u>	May 2000	Dubrow et al.	204/604
<u>6071478</u>	June 2000	Chow	422/81
<u>6074725</u>	June 2000	Kennedy	428/188
<u>6086740</u>	July 2000	Kennedy	204/601
<u>6087180</u>	July 2000	Gleaves	436/37
<u>6087181</u>	July 2000	Cong	436/37
<u>6100541</u>	August 2000	Nagle et al.	250/573
<u>6103199</u>	August 2000	Bjornson et al.	422/100
<u>6123798</u>	September 2000	Gandhi et al.	156/292
<u>6132685</u>	October 2000	Kercso et al.	422/104
<u>6149882</u>	November 2000	Guan et al.	422/211
<u>6287872</u>	September 2001	Schurenberg et al.	436/181
<u>6319719</u>	November 2001	Bhullar et al.	436/70
<u>6333019</u>	December 2001	Coppens	423/659
<u>6350617</u>	February 2002	Hindsgaul et al.	436/173
<u>6426226</u>	July 2002	Senkan	436/37
<u>6485692</u>	November 2002	Freitag et al.	422/130
<u>2002/0042140</u>	April 2002	Hagemeyer et al.	436/34

## FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	CLASS
27 14 939	October 1978	DE	
234 941	February 1985	DE	
196 32 779	February 1998	DE	
198 05 719	August 1999	DE	
198 06 848	August 1999	DE	
198 09 477	September 1999	DE	
198 55 894	June 2000	DE	
971 225	January 2000	EP	
0 870 541	November 2001	EP	
2 327 754	February 1999	GB	
WO 96/15576	May 1996	WO	
WO 96/35810	November 1996	WO	
WO 97/32208	September 1997	WO	

WO 98/07206	February 1998	WO
WO 98/14268	April 1998	WO
WO 98/16949	April 1998	WO
WO 98/56956	December 1998	WO
WO 99/10221	January 1999	WO
WO 99/19724	April 1999	WO
WO 99/30817	June 1999	WO
WO 99/34205	July 1999	WO
WO 99/41005	August 1999	WO
WO 99/43432	September 1999	WO
WO 99/48599	September 1999	WO
WO 99/59716	November 1999	WO
WO 99/64160	December 1999	WO
WO 99/64836	December 1999	WO
WO 00/07026	February 2000	WO
WO 00/14529	March 2000	WO
WO 00/21666	April 2000	WO
WO 00/22424	April 2000	WO
WO 00/32308	June 2000	WO
WO 00/32512	June 2000	WO
WO 0042212	July 2000	WO
WO 00/43766	July 2000	WO
WO 00/45172	August 2000	WO
WO 00/46594	August 2000	WO
WO 00/50172	August 2000	WO
WO 01/12327	February 2001	WO

## OTHER PUBLICATIONS

Jackel, K.P., "Microtechnology: Application Opportunities in the Chemical Industry" DEHEMA Monographs, vol. 132, VCH Verlagsgesellschaft 1996, pp. 29-50.

Ackelid, Ulf, et al. "Kinetic Studies of Diffusion Limited Gas-Surface Reactions By Spatially Resolved Gas Sampling: Reaction Rates and Sticking Coefficients in the H.sub.2 + O.sub.2 Reaction on Pt" Linkoping Studies In Science and Technology, Dissertations No. 392, 1995, pp. 122-133.

Zech et al., "Simultaneous Screening of Catalysts in Microchannels: Methodology and Experimental Setup" 00-00-1998, pp. 260-266 (XP-001006374).

Randhava, Ravi et al. "Advanced Configurations For Catalyst Research" Chemical Engineering Progress, vol. 70, No. 11 Nov. 1983, pp. 52-58.

Sie, S.T. "Reducing the Scale in Catalytic Process Research: Cost Savings" I 2 Procestechologie v. 7(3) 1991 IPRTEZ (Translation).

Rodemerck, Uwe, et al. "Parallel Synthesis and Testing Systems of Heterogeneous Catalysts".

Mirth, Gabriele et al. "Design and Application of a New Reactor for in Situ Infrared Spectroscopic Investigations of Heterogeneously Catalyzed Reactions" 1369 Applied Spectroscopy, 48(1994) Feb., No. 2, pp. 194-197.

G.M. Greenway, S.J. Haswell, D.O. Morgan, et al., "The Use of a Novel Microreactor for High Throughput Continuous Flow Organic Synthesis," Sensors and Actuators B-Chemical, 2000, 63, p. 153.

Burns et al., "Development of a Microreactor for Chemical Production," ALChE 2.sup.nd International Conference on Microreaction Technology; pp. 39-44 (1998).

Cooke, "Decreasing Gas Chromatography Analysis Times using a Multicapillary

Column," Abs. 403P, Book of Abstracts, PittCon''96 (1996).  
Ehrfeld et al., "Potentials and Realizations of Microreactors," DECHEMA Monographs vol. 132, pp. 1-28 (1995).  
Hanak et al., "Optimization Studies of Materials in Hydrogenated Amorphous Silicon Solar Cells," Photovoltaic Solar Energy Conference, Berlin (1979).  
Honick et al., "Heterogeneously Catalyzed Reactions in a Microreactor," DECHEMA Monographs vol. 132, pp. 93-107 (1995).  
Johansson et al., "Nanofabrication of Model Catalysts and Simulations of their Reaction Kinetics," J. Vac. Sci. Technol., 17:1 (Jan./Feb. 1999).  
Lowe et al., "Microreactor Concepts for Heterogeneous Gas Phase Reactions," AlChE 2.sup.nd International Conference on Microreaction Technology, pp. 63-73 (1998).  
Matlosz et al., "Microsectioned Electrochemical Reactors for Selective Partial Oxidation," AIChE 2.sup.nd International Conference on Microreaction Technology, pp. 54-59 (1998).  
S.M. Sze, "Semiconductor Sensors," Chap. 2, pp. 17-96, John Wiley & Sons, Inc. (1994).  
Srinivasan et al., "Micromachined Reactors for Catalytic Partial Oxidation Reactions," AlChE Journal, vol. 43, No. 11, pp. 3059-3069 (1997).  
Tonkovich et al., "The Catalytic Partial Oxidation of Methane in a Microchemical Reactor," AlChE 2.sup.nd International Conference on Microreaction Technology, pp. 45-53 (1998).  
van Dover et al., "Discovery of a Useful Thin-Film Dielectric Using a Composition-Spread Approach," Nature, vol. 392, No. 12, pp. 162-164 (1998).  
Bunshah, "Handbook of Deposition Technologies for Films and Coatings," 2.sup.nd Ed., Noyes Publications (1994).  
Van den Berg et al., "Module Concept for Miniature Chemical Systems," DECHEMA Monographs vol. 132 (1995), pp. 109-123.

ART-UNIT: 1743

PRIMARY-EXAMINER: Warden; Jill

ASSISTANT-EXAMINER: Quan; Elizabeth

ABSTRACT:

A chemical processing microsystem useful for identifying and optimizing materials (e.g., catalysts) that enhance chemical processes or for characterizing and/or optimizing chemical processes is disclosed. The chemical processing microsystem comprises a plurality of microreactors 600 and, in a preferred embodiment, a plurality of microseparators 900 integral with the chemical processing microsystem 10. The microreactors 600 are preferably diffusion-mixed microreactors formed in a plurality of laminae that include a modular, interchangeable candidate-material array 100. The material array 100 comprises a plurality of different candidate materials (e.g., catalysts), preferably arranged at separate, individually addressable portions of a substrate (e.g., wafer). The microseparators 900 are similarly formed in a plurality of laminae that include a modular, interchangeable adsorbent array 700. The adsorbent array 700 comprises one or more adsorbents, preferably arranged at separate, individually addressable portions of a substrate to spatially correspond to the plurality of different candidate materials. Modular microfluidic distribution systems are also disclosed. The chemical processing microsystem can be integrated into a material evaluation system that enables a comprehensive combinatorial material science research program.

24 Claims, 88 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	Info	Drawings
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	------	----------

☐ 11. Document ID: US 6680044 B1

L3: Entry 11 of 11

File: USPT

Jan 20, 2004

US-PAT-NO: 6680044

DOCUMENT-IDENTIFIER: US 6680044 B1

TITLE: Method for gas phase reactant catalytic reactions

DATE-ISSUED: January 20, 2004

## INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Tonkovich; Anna Lee Y.	Marysville	OH		
Wang; Yong	Richland	WA		
Fitzgerald; Sean P.	Hilliard	OH		
Marco; Jennifer L.	South Charleston	OH		
Roberts; Gary L.	West Richland	WA		
VanderWiel; David P.	Hilliard	OH		
Wegeng; Robert S.	Richland	WA		

## ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Battelle Memorial Institute	Richland	WA			02

APPL-NO: 09/640903 [PALM]

DATE FILED: August 16, 2000

## PARENT-CASE:

RELATED APPLICATIONS This application is a Continuation-In-Part of U.S. patent application Ser. No. 09/375,614, now U.S. Pat. No. 6,488,838, filed Aug. 17, 1999, which is incorporated herein in full, as if reproduced below.

INT-CL: [07] C01 B 3/26

US-CL-ISSUED: 423/652; 423/418.2, 423/437.2, 252/373

US-CL-CURRENT: 423/652; 252/373, 423/418.2, 423/437.2

FIELD-OF-SEARCH: 208/108, 208/143, 208/209, 252/373, 423/418.2, 423/437.2, 423/648.1, 423/651, 423/652, 423/656, 423/659, 568/924, 570/101, 570/123, 585/250, 585/654, 431/7

## PRIOR-ART-DISCLOSED:

## U.S. PATENT DOCUMENTS

PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
4062808	December 1977	Gandhi et al.	252/454

<u>4268279</u>	May 1981	Shindo et al.	55/16
<u>4340501</u>	July 1982	Davidson	252/373
<u>4795618</u>	January 1989	Laumen	422/202
<u>4975406</u>	December 1990	Frestad et al.	502/302
<u>5015444</u>	May 1991	Koga et al.	422/195
<u>5021388</u>	June 1991	Fridez	502/261
<u>5047381</u>	September 1991	Beebe	502/304
<u>5051241</u>	September 1991	Pfefferle	422/180
<u>5270127</u>	December 1993	Koga et al.	429/17
<u>5366719</u>	November 1994	van Wingerden et al.	423/659
<u>5387398</u>	February 1995	Mueggenburg et al.	422/186
<u>5397656</u>	March 1995	Morimoto et al.	429/17
<u>5417938</u>	May 1995	Shelden et al.	422/196
<u>5422331</u>	June 1995	Galligan et al.	502/333
<u>5426442</u>	June 1995	Haas	343/778
<u>5440872</u>	August 1995	Pfefferle	60/39.06
<u>5512250</u>	April 1996	Betta et al.	422/173
<u>5518697</u>	May 1996	Dalla Betta et al.	422/173
<u>5533890</u>	July 1996	Holst et al.	431/5
<u>5534328</u>	July 1996	Ashmead et al.	428/166
<u>5565009</u>	October 1996	Ruhl et al.	48/197R
<u>5609834</u>	March 1997	Hamada et al.	422/196
<u>5611214</u>	March 1997	Wegeng et al.	62/498
<u>5674301</u>	October 1997	Sakai et al.	48/61
<u>5733347</u>	March 1998	Lesieur	48/61
<u>5811062</u>	September 1998	Wegeng et al.	422/129
<u>5858314</u>	January 1999	Hsu et al.	422/211
<u>5866734</u>	February 1999	Flick et al.	585/260
<u>5976472</u>	November 1999	Chatterjee et al.	422/130
<u>6036927</u>	March 2000	Chatterjee et al.	422/211
<u>6040266</u>	March 2000	Fay et al.	502/439
<u>6048194</u>	April 2000	Pfefferle et al.	431/115
<u>6056932</u>	May 2000	von Hippel et al.	423/376
<u>6117578</u>	September 2000	Lesieur	429/19
<u>6129973</u>	October 2000	Martin et al.	428/166
<u>6140266</u>	October 2000	Corrigan et al.	502/439
<u>6159358</u>	December 2000	Mulvaney, III et al.	208/46
<u>6159434</u>	December 2000	Gonjo et al.	422/191
<u>6165633</u>	December 2000	Negishi	429/17
<u>6168765</u>	January 2001	Romatier et al.	422/200
<u>6190624</u>	February 2001	Romatier	422/200
<u>6192596</u>	February 2001	Bennett et al.	34/76
<u>6200536</u>	March 2001	Tonkovich et al.	422/177
<u>6228341</u>	May 2001	Hebert et al.	423/352
<u>6274101</u>	August 2001	Sechrist	422/198
<u>6488838</u>	December 2002	Tonkovich et al.	208/108

## FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	CLASS
0 547 012	June 1993	EP	
0 869 842	October 2001	EP	
05-105405	April 1993	JP	
WO 96/32188	October 1996	WO	
WO 97/39490	October 1997	WO	
WO 00/06295	February 2000	WO	
WO 00/32512	June 2000	WO	
WO 00/45940	August 2000	WO	

## OTHER PUBLICATIONS

"Development of Reformer for Fuel Cell System," Watanabe et al., Ishikawajima-Harima Engineering Review, UDC 621.352:66.045 (1988). Includes english translation.

AN Pestryakov et al., "Foam Metal Catalysis With Intermediate Support For Deep Oxidation of Hydrocarbons", p. 347-352. 1994.

AN Pestryakov et al., "Metal-Foam Catalysts With Supported Active Phase For Deep Oxidation of Hydrocarbons", p. 167-172. 1995.

AY Tonkovich et al., "The Catalytic Partial Oxidation of Methane in A Microchannel Chemical Reactor", p. 1-11. PNNL.

AY Tonkovich et al., "Microchannel Reactors for Fuel Processing Applications. I. Water Gas Shift Reactor", p. 2947-2951. 1999.

G. Wiessmeier et al., "Microreaction Technology: Development of a Micro Channel Reactor and Its Application in Heterogeneously Catalyzed Hydrogenations", p. 152-153. 1998.

G. Weissmeier et al., Strategy for the Development of Micro Channel Reactors for Heterogeneously Catalyzed Reactions, p. 24-32. 1998.

"Catalytic Combustion In A Sintered Metal Reactor With Integrated Heat Exchanger," Mulder et al., Applied Thermal Engineering, pp. 825-836 (1997).

"Technology And Applications Of Microengineered Reactors," Gavrilidis et al., Trans. IchemE, vol. 80, Part A, pp. 3-30, Jan. 2002.

"Development and study of metal foam heat-exchanging tubular reactor: Catalytic combustion of methane combined with methane steam reforming," Corma et al., Studies in Surface Science and Catalysis, 130, pp. 2759-2764 (2000).

"Microreactor Concepts for Heterogeneous Gas Phase Reactions," Lowe et al., Process Mini: 2nd International Conf. On Micro Tech., pp. 63-74 (1998).

"New Operating Regimes and Applications Feasible with Microreactors," Franz et al., Process Mini: 2nd International Conf. On Micro Tech., pp. 33-38 (1998).

"Monolithic Catalyst Supports with Foam Structure," Leonov et al., React. Kinet. Catal. Lett., pp. 259-267 (1997).

"On the Reported Attempts to Radically Improve the Performance of the Steam Methane reforming Reactor," Adris et al., Can. J. Of Chem. Eng., vol. 74, pp. 177-185, 1996.

"Catalytic combustion of natural gas as the role of on-site heat supply in rapid catalytic CO.sub.2 -H.sub.2 O reforming of methane," Inui et al., Catalysis Today, 26, pp. 295-302 (1995).

"A Novel Fixed Bed Catalyst for the Direct Combination of H.sub.2 and O.sub.2 to H.sub.2 O.sub.2," Kosak, Catalysis and, pp. 115-124 (1995).

"Metal and Coated-Metal Catalysts," Twigg et al., Chapter 3, pp. 59-89.

ART-UNIT: 1754

PRIMARY-EXAMINER: Silverman; Stanley S.



ASSISTANT-EXAMINER: Medina; Maribel

ATTY-AGENT-FIRM: May; Stephen R. Rosenberg; Frank S.

## ABSTRACT:

The present invention provides chemical reactors and reaction chambers and methods for conducting catalytic chemical reactions having gas phase reactants. In preferred embodiments, these reaction chambers and methods include at least one porous catalyst material that has pore sizes large enough to permit molecular diffusion within the porous catalyst material.

92 Claims, 28 Drawing figures

Full	Title	Citation	Front	Review	Classification	Date	Reference			Claims	DOC	Draw
------	-------	----------	-------	--------	----------------	------	-----------	--	--	--------	-----	------

Clear	Generate Collection	Print	Fwd Refs	Bkwd Refs	Generate OACS
-------	---------------------	-------	----------	-----------	---------------

Term	Documents
HEAT	3423803
HEATS	129036
EXCHANGER\$1	0
EXCHANGER	325980
EXCHANGERA	11
EXCHANGERB	2
EXCHANGERC	1
EXCHANGERE	14
EXCHANGERF	2
EXCHANGERG	23
EXCHANGERI	35
(L2 AND HEAT EXCHANGER\$1 ) . PGPB, USPT, USOC, EPAB, JPAB, DWPI .	11

There are more results than shown above. [Click here to view the entire set.](#)

Display Format:  [Previous Page](#)[Next Page](#)[Go to Doc#](#)